EQUIPMENT

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EFFECT OF GEOMETRIC PARAMETERS ON THE PRODUCTIVITY OF A SCREW CONVEYOR VACUUM-PRESS WHEN MOLDING CERAMIC GREEN MIXES

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The productivity of a screw conveyor vacuum press in molding ceramic green mixes is studied as a function of the specific pressure, productivity losses due to wear of the press, and geometric factors affecting productivity. The results of a determination of the geometric parameters affecting the productivity of a press are presented.

Key words: ceramic green mixes, molding, screw conveyor vacuum-press, productivity.

The productivity of a screw conveyor vacuum press can decrease in the following cases:

the moisture content of the clay paste decreases; this is observed with periodic pressing of pastes in the screw and head of the press; in this case water (or vapor) must be added in amounts so that the moisture content is at least 18%;

the amount of the clay paste fed into the clay mixer of the press decreases below the normal amount; this deficiency is eliminated by regulating the operation of the equipment preparing the initial material and of the transporting mechanism;

the gap between the screw blades and the jacket, located in the body of the press, increases to such an extent (3 – 5 mm and larger) that the paste moves backward; this deficiency is eliminated by building up the screw blades and the jacket to dimensions such that the gap between them is 1.5 – 3.0 mm.

The densification of porcelain paste plays an important role in the production of ceramic articles; this depends on the specific pressing pressure p. The higher the specific pressure, the larger the compaction factor α is [1]. The dependence of the compaction factor α on the specific pressing pressure is presented in Fig. 1.

For values of the specific pressing pressure above 10^5 Pa the value of α remains practically the same [1].

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The productivity loss factor K due to slipping of the paste and its backward motion in the gaps x between the screw blades and the cylinder jacket of the press is taken on the basis for the experimental data presented in Table 1 and Fig. 2.

The lift angle of the spiral line of the screw has a large effect on the productivity of a screw conveyor vacuum-press. The coefficient K_1 of this effect is determined by the lift angle of the spiral line as well as how finely the surface of the screw blades is worked. The lift angle of the median spiral line is given by the relation

$$\tan \beta = \frac{t}{\pi D_{av}},$$

where β is the lift angle of the spiral line, deg; t is the pitch of the screw, m; and, D_{av} is the average diameter of the screw, equal to the one-half the sum of the outer diameter of a blade and the diameter of the hub, m.

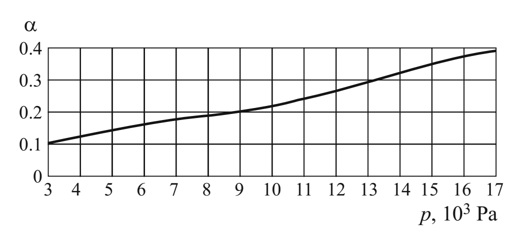

Fig. 1. Compaction factor α versus the specific pressing pressure p.

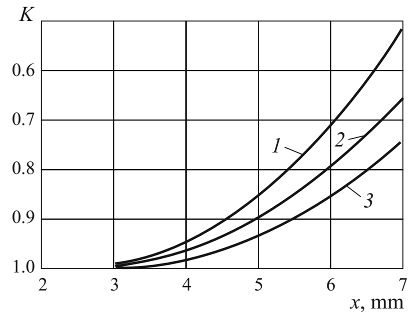

Fig. 2. Productivity factor K versus the gap x (between the cylinder of the press and the screw), affecting the slip-through of the paste.

The pressing of the pastes by the screw involves a loss of energy as a result of the rubbing of the screw blades against the paste. The efficiency η of the screw depends on the lift angle of the spiral line and the friction between the screw and the paste being pressed:

$$\eta = \frac{\tan \beta}{\tan (\beta + \varphi)},$$

where φ is the friction angle.

The efficiency of the screw of the press increases with increasing lift angle of the spiral line and decreasing angle of friction between the screw and the paste.

However, experiments have shown that an increase of the lift angle of the spiral line of the screw by more than 22 – 25° increases the amount of paste slipping through and decreases the productivity.

Polishing the surfaces of the screw blades is not cost-effective. In addition, the roughness of the polished surface increases with use approximately to GOST 2789–73 roughness class 8 – 9. For this reason, usually, the screw surfaces of case screw blades are polished (additionally ground) to roughness class 7. The friction angle between the ceramic paste and such a metal surface is 20 – 28° depending on the plasticity of the paste. In practice, the lift angle of the spiral line of the screw is 16 – 25°.

The productivity factor K_1 as a function of the lift angle of the spiral line of the screw is shown in Fig. 3 (the rotation rate of the screw $n = 25$ min^{-1}, the moisture content of the screw is 18%, and the surfaces of the screw blades are worked to roughness class 8).

TABLE 1.

Gap in the x direction, mm	Factor K for clay with plasticity		
	high (category 1)	medium (category 2)	low (category 3)
Up to 3	1.00	1.00	1.00
4	0.96	0.97	0.99
5	0.86	0.91	0.95
6	0.72	0.80	0.87
7	0.51	0.65	0.75

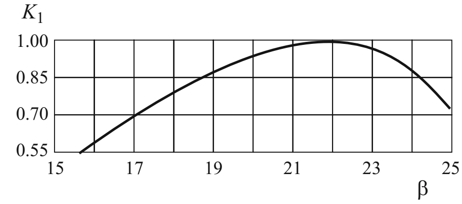

Fig. 3. Productivity factor K_1 versus the lift angle β of the spiral line of the screw (rotation rate of the screw 25 min^{-1}, moisture content of the paste 18%).

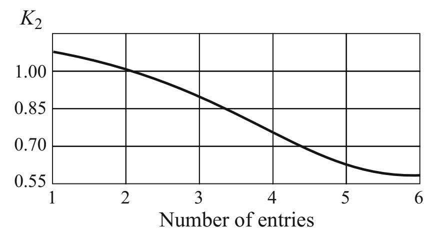

Fig. 4. Coefficient K_2 versus the number of entries of the expressing blade of the screw (the rotational frequency of the screw is 25 min^{-1}, the moisture content of the paste is 18%).

As the rotation rate of the screw changes, the character of the curve remains approximately the same as in Fig. 3 but with a corresponding increase or decrease of the productivity. In calculations of the parameters of an acting press the value of K_1 is taken according to the lift angle of the spiral line.

The number of entries of the expressing blade affects the productivity of the press. A single-entry expressing blade gives the lowest resistance of the molded paste as the paste enters the head of the press, i.e., it gives the highest productivity. But then the paste is fed in jerks, unevenly, which causes internal resistance in the molding bar and nonuniform density of the paste and ultimately increases the number of rejects formed during drying and firing.

The larger the number of entries of the expressing blade, the more uniformly the molding bar exits the press and the higher the quality of the press articles is. However, then the resistance to pushing the paste into the head of the press increases and, correspondingly, the productivity decreases. For this reason, a two-entry expressing blade is used in practice.

If the productivity of the press is not decisive for the design of the press, and the main requirement is to obtain high-quality articles with elimination of rejects such as articles with striae and S-shaped cracks, then the expressing blade can be made so as to enter three or more times up to six entries.

The dependence of the productivity factor K_2 on the number of entries of the expressing blade is presented in Fig. 4 for the same moisture content of the paste and rotation rate of the screw as for K_1.

The slipping of the paste along the screw blades is characterized by the factor K_3, which is chosen on the basis of the experimental data depending on the category of the plasticity of the molded paste.

Paste plasticity	K_3
Category 1	0.20
Category 2	0.23
Category 3	0.27

The problem of is simply solved when calculating the productivity of a press Q (m^3/h) for concrete conditions (with known physical – mechanical parameters of the molded ceramic paste and for a definite shape of the articles). All required data are substituted into the relation [3]

$$Q = 60\pi n\left(\frac{D^2 - d^2}{4}\right)(t - \delta)(1 - \alpha)KK_1K_2K_3,$$

where n is the rotation rate of the screw, min^{-1}; D is the diameter of the expressing blade of the screw, m; d is the diameter of the hub of the screw, m; t is the pitch of the spiral line of the screw, m; δ is the thickness of a screw blade, m; α is the compaction factor for the molded paste; K, K_1, K_2, and K_3 are productivity loss factors, which depend on the gap between the screw blades and cylinder jacket of the press, on the lift angle of the spiral line of the screw, on the number of entries of the expressing blade, and on the plasticity of the molded paste, respectively.

In summary, the effect of the geometric parameters on the productivity of presses shows that their structural and operating features also depend on the properties of the molded paste which must be carefully prepared for feeding into the press. To this end the following must be provided in vacuum presses:

moistening with vapor;

double de-gassing;

careful grinding of the paste entering the vacuum-press;

use of double-shaft and elongated mixers; and,

automatic maintenance of the required moisture content of the molded bar.

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